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Anti-Psoriatic activity of *Coffee liberica* pulp extract on Imiquimod-induced Psoriasis-like dermatitis in Balb/C mice

Mishalini Vijayakumaran[1], Monisha Thanka Velu[2], Azrina Zainal Abidin[2], Hasnah Bahari[3], Fezah Othman[4], Goh Khang Wen[5,6], Mahardian Rahmadi[7,8] and Santhra Segaran Balan[2*]

[1]*School of Graduate Studies, Management and Science University, Shah Alam, Malaysia*
[2]*Department of Diagnostic and Allied Health Sciences, Faculty of Health and Life Sciences, Management and Science University, Shah Alam, Malaysia*
[3]*Department of Human Anatomy, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang, Malaysia*
[4]*Department of Biomedical Sciences, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang, Malaysia*
[5]*Faculty of Business and Communication, INTI International University, Nilai, Malaysia*
[6]*Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Padang, Indonesia*
[7]*Department of Pharmacy Practice, Faculty of Pharmacy, Universitas Airlangga, Surabaya, Indonesia*
[8]*Biomedical Pharmacy Research Group, Faculty of Pharmacy, Universitas Airlangga, Surabaya, Indonesia*

ABSTRACT

Background: Psoriasis, also known as Psoriasis (Pso), is a persistent skin disorder characterized by erythematous, indurated, scaly, itchy, and often painful plaques. Although conventional medicine has been employed to treat psoriasis, it may cause adverse effects owing to its long-term use. Consequently, alternative medicine has become a popular option to address this issue. *Coffee liberica* pulp, a commonly overlooked waste product, has been found to have numerous benefits for humans.

Aim: This study investigated the effectiveness of *Liberia coffee* pulp extract using an imiquimod (IMQ)-induced mouse model that replicated several features of psoriasis in humans.

Methods: The study involved applying IMQ cream and other topical treatments to the shaved dorsal skin of mice. The psoriasis Area and Severity Index score, body weight, organ weight, expression of interleukins in the skin and serum, and full blood count were measured.

Results: The results showed significant changes ($p < 0.05$) in skin weights in the negative control group compared with other groups. No significant changes in other organ weight were observed in any groups. However, the full blood count revealed significant changes ($p < 0.05$) in haemoglobin and white blood cell counts. The levels of interleukin 17a, interleukin 22, and interleukin 23 levels showed significant differences ($p < 0.05$) between the positive and treatment groups.

Conclusion: This study found that *C. liberica* pulp has anti-inflammatory and antioxidant properties that help reduce skin inflammation. These findings suggest that *C. liberica* is a cost-effective source of natural antioxidants that can be used to alleviate psoriasis.

Keywords: Psoriasis, *Coffee liberica* pulp, Imiquimod, Anti-psoriatic activity, psoriasis Area and Severity Index (PASI) score.

Introduction

Psoriasis, commonly referred to as Psoriasis (Pso), is non-contagious, systemic immune-mediated skin disorders. The characteristic symptoms of Pso include the growth of erythematous, indurated, scaly, and itchy skin plaques, often accompanied by pain (Armstrong and Read 2020). The rapid growth of skin cells in Pso is triggered by inflammatory chemicals produced by T-cells, and defective inflammatory responses are essential (Qi *et al.,* 2021). Acute dermatitis presents as a blistered and swollen red rash, whereas chronic dermatitis is characterised by a long-standing, thickened, and scratched area of the skin that is often darker than the surrounding

***Corresponding Author:** Santhra Segaran Balan. Department of Diagnostic and Allied Health Sciences, Faculty of Health and Life Sciences, Management and Science University, Shah Alam, Malaysia. Email: *santhra@msu.edu.my*

area. Psoriatic scales typically appear as whitish-silver, thick, and red patches with well-defined edges and a scaly appearance. They can also cause itching and discomfort in affected individuals (Raj *et al.,* 2021). Moreover, the presence of plaques can lead to feelings of embarrassment and low self-esteem among affected individuals (Raj *et al.,* 2021). Some potential drawbacks may arise when using certain treatments for psoriasis. For instance, overproduction of skin cells can exacerbate the condition and cause discomfort to patients. Additionally, the use of this treatment may decrease the effectiveness of other medications that the patient may be taking, requiring them to adjust their dosage or switch to a different treatment.

Coffee liberica pulp is derived from *c. liberica*, which is primarily cultivated in the Philippines, Malaysia, and Indonesia. Pumaras *et al.* (2024) indicated that *C. liberica* is typically grown in the mountainous regions of West Africa and Southeast Asia. The distinct smell that emanates from beans during roasting, reminiscent of durian, makes *C. liberica* an acquired taste. As a result, *C. liberica* beans are known for their strong aroma, which can be quite pungent and may be used by those who are not accustomed to it. Coffee pulp, which is the dried skin of coffee cherries, is a by-product of coffee production and has been found to possess various medicinal properties. Coffee pulp contains bioactive compounds with anti-inflammatory, antioxidant, and antimicrobial properties, making it a promising source for the development of natural products in the pharmaceutical industry. Coffee pulp is a rich source of chlorogenic acid, which has been associated with various health benefits, including reducing the risk of type 2 diabetes and lowering blood pressure. Pulped skins, also known as coffee pulp, were collected after the seeds had been removed from the cherries. These skins are typically discarded during the coffee production process but can potentially be utilised for various applications in the pharmaceutical industry. *Coffee liberica* has a unique and distinct taste, and its coffee pulp has potential medicinal properties that could be harnessed for various applications in the pharmaceutical industry.

Imiquimod cream is often used to treat actinic keratoses on the face or scalp as well as superficial basal cell carcinoma in various areas of the body, including the trunk, neck, arms, hands, legs, and feet. Additionally, it can be effective in treating other skin conditions such as solar lentigines, seborrheic keratoses, and Bowen's disease (Nerurkar *et al.,* 2017). Imiquimod cream functions by increasing immune system activity to treat genital and anal warts. In this study, imiquimod cream was used to induce psoriasis-like dermatitis in a mouse model; and is treat with *Coffee liberica* pulp extract align with Sustainable Development Goals 3 (Good health well-being) and 12 (Responsible Consumption and Production).

Although the anti-inflammatory and antioxidant properties of coffee bioactives have been widely reported, most investigations have centered on coffee beans or green coffee extracts, leaving the potential of coffee pulp, a polyphenol-rich by-product, largely unexplored. This study advances current knowledge by evaluating the protective and immunomodulatory effects of coffee pulp extract in an imiquimod-induced psoriasis model, thereby providing new insights into its role in regulating the IL-23/Th17 cytokine pathway and improving systemic hematological parameters. These findings highlight coffee pulp as a novel, sustainable source of bioactives with therapeutic potential in psoriasis management.

Materials and Methods

Sample identification and ethanol extraction of Coffee liberica pulp (LCP)

Sample LCP (waste product) was obtained from the Federal Agricultural Marketing Authority of Banting, Selangor. Subsequently, the LCP was cleaned under running tap water to remove any external materials. LCP was oven-dried at 60°C for 24 hours. For ethanol extraction, 100 g of LCP was diluted with 900 ml of ethanol in a conical flask. Homogenised LCP with ethanol was filtered using Whatman paper No. 1 after 4 days. The supernatant was kept in a Scott bottle, and the sediment was diluted with 900 ml ethanol for another 4 days. This procedure was repeated for an additional 4 days, and at the end of 12 days. All the supernatants were collected and freeze dry. The sample was kept and stored at −20°C until further use (Balan *et al.,* 2021).

Preparation of C. liberica pulp cream (LCPC)

A homogenous mixture of the extract and a cream base (sourced from Popoemart, Malaysia) was prepared according to the previously described method (Balan *et al.,* 2024). The cream base used in this process did not contain any fragrance and was composed of purified water, cetearyl alcohol, glycerin, and phenoxyethanol. Table 1 provides the amounts of LC extract and cream

Table 1. The required amounts of LC extract and base cream to prepare 10 g of each cream concentration (1%, 5% and 10%, w/w).

LCPC cream concentration (%)	LC extract (g)	Base cream (g)	Total (g)
1	0.5	9.5	10
5	1.0	9.0	10
10	2.0	8.0	10

Abbreviation: *Coffee liberica* pulp cream (LCPC), *Coffee liberica* (LC).

base required to produce 1%, 5%, and 10% (w/w) LC cream, respectively.

Animal studies

A total of 30 BALB/c mice (20–25 g) were obtained from Universiti Putra Malaysia (UPM), Serdang, Selangor. After a one-week acclimatization period, the animals were randomly assigned to six groups ($n = 5$). The dorsal hair of each mouse was shaved to create a uniform 2 × 4 cm² area for topical application. All animals were maintained under controlled conditions (22°C ± 2°C, 12-hour light/dark cycle) with free access to food and water. BALB/c mice were chosen because they exhibit a well-characterized Th1/Th17 immune response, making them a reliable model for IMQ-induced psoriasis-like dermatitis. This strain provides consistent skin reactions, reproducible inflammatory profiles, and has been widely used.

- Group 1 (N; Normal Control): Received vaseline cream only, applied once daily for 15 days.
- Group 2 (NC; Negative Control): For 15 consecutive days, this group of mice received a daily topical application of 62.5 mg of 5% imiquimod cream on the shaved dorsal area to induce psoriasis-like skin inflammation.
- Group 3 (PC; Positive Control): The animals in this group were induced with IMQ in the same manner as those in Group II. Beginning on day 7, 0.1% corticosteroid (clobetasol propionate cream) was topically applied once daily for eight consecutive days as the positive control treatment (standard reference in IMQ-induced psoriasis models).
- Group 4 (TCW1): The mice in this group received a topical application of IMQ to induce skin Psoriasis, like Group NC. On the 7th day, 62.5 mg of LCPC 1% cream was applied topically for the following 8 days.
- Group 5 (TCW2): The mice in this group underwent topical application of IMQ to induce skin psoriasis, like Group NC. On the 7th day, 62.5 mg of LCPC 5% cream was applied topically for the subsequent 8 days.
- Group 6 (TCW3): The mice in this group underwent topical application of IMQ to induce skin psoriasis, like Group NC. On the 7th day, 62.5 mg of LCPC 10% cream was applied topically for the subsequent 8 days.

Psoriasis Area and Severity Index (PASI) scoring system, body weight assessment, and organ weight assessment

Scoring was performed on a 2 × 4 cm² area of the dorsal skin that was shaved one day prior to the application of Vaseline and IMQ cream. The PASI score was recorded for erythema, thickness, and scaling of the skin on day 15. The score was assigned on a scale of 0–4 for erythema, thickness, and scaling, with 0 indicating none, 1 indicating slight, 2 indicating moderate, 3 indicating marked, and 4 indicating very marked erythema (Balan *et al.,* 2024). The body weight of the mice was measured on days 1, 7, and 17. During the experimental period, all groups of mice were weighed, and their weights were recorded. After culling all mice, the organs of each mouse's skin, spleen, kidney, liver, and heart were isolated and weighed.

Inflammatory factor determination

Blood samples (3 ml) were collected from the mice via cardiac puncture and transferred into plain tubes. The samples were then centrifuged at 2,500 rpm for 15 minutes to separate the serum, which was stored for subsequent analysis. In addition, the dorsal skin of each mouse was dissected and immediately snap frozen in liquid nitrogen for further examination. The concentrations of key pro-inflammatory cytokines, including IL-17A, IL-22, and IL-23, were quantified using commercially available enzyme-linked immunosorbent assay kits (Sigma-Aldrich, St. Louis, MO, USA), following the manufacturer's protocols.

Statistical analysis

Data analysis was performed using the Statistical Package for the Social Sciences 25.0 Windows software. The differences between the treatment and control groups were assessed using one-way analysis of variance (ANOVA), followed by a post hoc LSD test. Data are expressed as the mean ± standard error mean (SEM).

Ethical approval

Animal study conducted with approval of Animal Ethic Committee Management and Science University (EA-L3-01-FHLS-2024). Date approval 14 March 2024.

Results

Impact of Coffee liberica pulp on body weight on day 1, 7, and 15

As shown in Figure 1, all groups exhibited a gradual increase in body weight from day 1 to day 15. Although minor variations were observed among groups—with TCW3 showing the highest mean body weight and TCW2 the lowest—these differences were not statistically significant ($p > 0.05$). Overall, the consistent weight gain across all groups indicates normal physiological growth, suggesting that neither imiquimod application nor the treatments produced adverse effects on body weight regulation.

Impact of Coffee liberica pulp on the weight of organ

Based on Table 2, the NC group exhibited a significant ($p < 0.05$) increase in skin weight compared to the control (C), reflecting epidermal thickening and inflammation characteristic of psoriatic lesions. Treatment groups, particularly TCW3, also displayed higher skin weight than control, which may indicate ongoing epidermal remodeling or partial recovery following treatment rather than active hyperproliferation. In contrast, the positive control (PC) group demonstrated near-normal skin weight, signifying effective suppression of inflammation. Splenomegaly observed in the NC group confirms systemic immune activation induced by imiquimod, while both PC and treatment groups

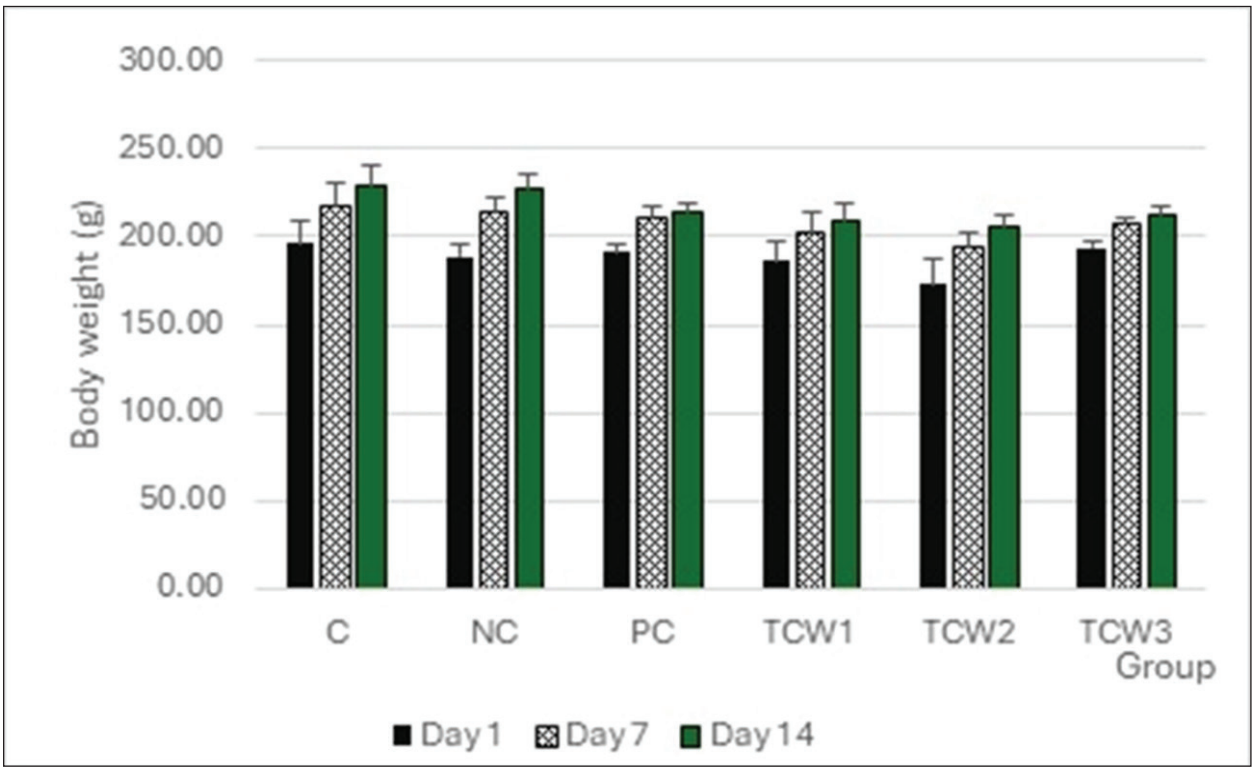

Fig. 1. Body weight of mice at day 1, day 7 and day 14. Data are expressed as mean ± SEM and were analyzed by one-way ANOVA, followed by post hoc LSD. C, normal control; NC, negative control; PC, positive control; TCW1, mice treated with 1% extract; TCW2, mice treated with 5% extract, TCW3, mice treated with 10% of extract. Significant level set at $p < 0.05$.

Table 2. Impact of *Coffee liberica* pulp on Balb/C mice organ weight such as skin, spleen, kidney, liver and heart.

Group	Skin		Spleen		Kidney		Liver		Heart	
	(g)	%BW	(g)	%BW	(g)	%BW	(g)	%BW	(g)	%BW
C	1.02 ± 0.26	0.45	0.52 ± 0.06	0.23	8.33 ± 0.07	3.64	1.70 ± 0.12	0.74	0.95 ± 0.07	0.42
NC	1.49 ± 0.22	0.66	0.62 ± 0.05	0.27	7.54 ± 0.24	3.32	1.54 ±0.14	0.68	0.83 ±0.06	0.37
PC	1.00 ± 0.22	0.47	0.40 ±0.06	0.19	7.83 ± 0.56	3.66	1.58 ± 0.13	0.74	0.89 ± 0.03	0.42
TCW1	1.35 ± 0.20	0.65	0.50 ± 0.04	0.24	6.80 ± 0.27	3.25	1.46 ± 0.10	0.70	0.87 ± 0.08	0.42
TCW2	1.51 ± 0.14	0.73	0.54 ± 0.07	0.26	7.23 ± 0.55	3.51	1.49 ± 0.07	0.72	0.82 ± 0.04	0.40
TCW3	1.65 ± 0.10	0.77	0.57 ± 0.06	0.27	7.00 ± 0.23	3.29	1.51 ± 0.06	0.71	0.81 ± 0.05	0.38

Data are expressed as mean ± SEM and were analyzed by one-way ANOVA, followed by post hoc LSD. C, normal control; NC, negative control; PC, positive control; TCW1, mice treated with 1% extract; TCW2, mice treated with 5% extract, TCW3, mice treated with 10% of extract. Significant level set at $p < 0.05$.

showed reduced spleen size, suggesting attenuation of systemic inflammation and restoration of immune homeostasis.

The NC group had reduced kidney weight compared to controls. This may indicate systemic stress or early renal involvement. Kidney weights in all treatment groups improved, particularly TCW2 close to normal. No significant changes in heart weight across all groups. Liver weights across groups remained relatively stable, though NC group and PC group showed minimal changes.

Anti-Psoriatic activity of Coffee liberica pulp on Balb/C mice

Figure 2 shows the cumulative PASI scores for erythema, thickness, and scaling. PASI score for the control group was negligible for all parameters. For the NC, the PASI score was higher for all the parameters. The PASI score, particularly for erythema, was significantly higher in the NC group than that in the other groups. However, TCW1, TCW2, and TCW3 showed a reduction in the PASI score for all three parameters compared with the NC group. The graph

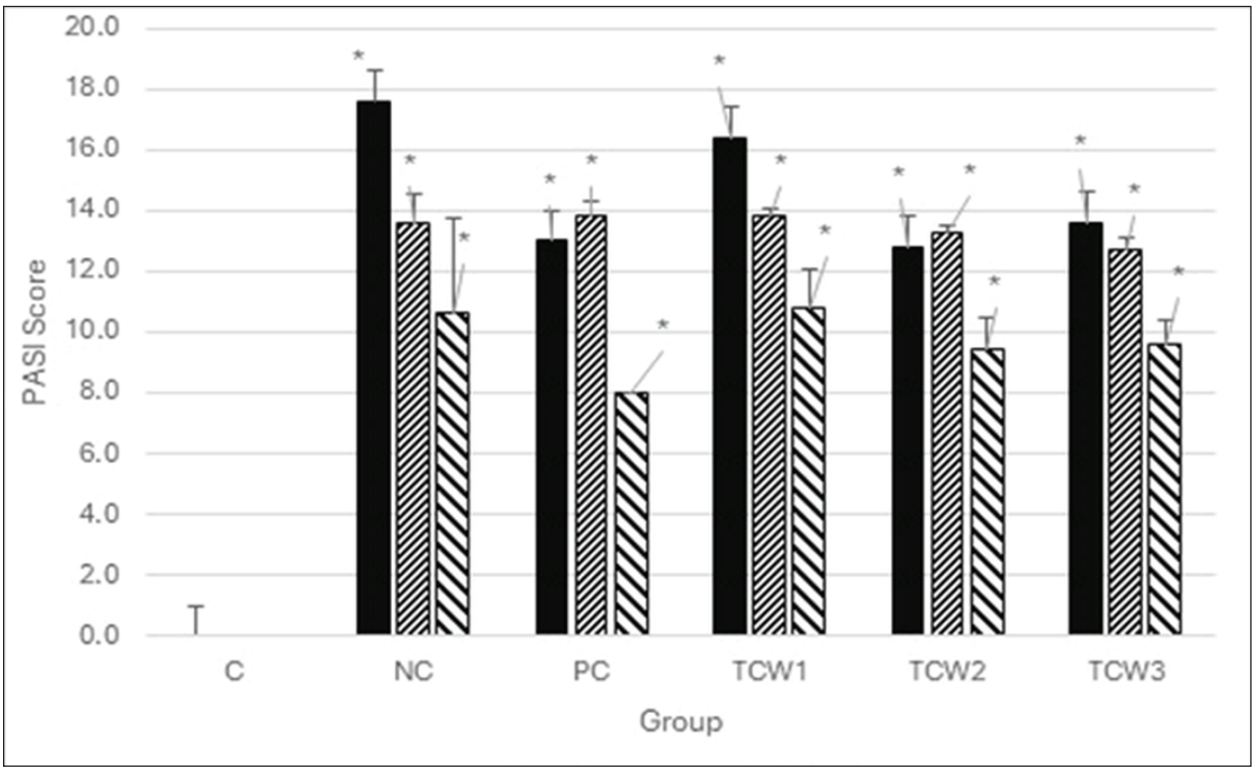

Fig. 2. PASI score on IMQ induced mice. Data are expressed as mean ± SEM and were analyzed by one-way ANOVA, followed by post hoc LSD. C, normal control; NC, negative control; PC, positive control; TCW1, mice treated with 1% extract; TCW2, mice treated with 5% extract, TCW3, mice treated with 10% of extract. Significant level set at $p < 0.05$.

indicates that the treatments (TCW1, TCW2, and TCW3) seem to be effective in lowering PASI scores for erythema, thickness, and scaling compared to the NC. This suggests that these treatments are useful for treating psoriatic symptoms such as dermatitis. Figure 3 shows the phenotypical observations of the dorsal skin in mice with IMQ-induced psoriasis.

Effect of Coffee liberica pulp on full blood count (FBC)

Based on Table 3, the NC group shows a significant ($p < 0.05$) reduction in hemoglobin and red blood cell (RBC) count compared to the C group, indicating anemia associated with inflammation. PC group showed elevated hemoglobin and RBC, reflecting effective reversal of inflammatory anemia. Among treatment groups, TCW 1 and TCW 3 showed significant ($p < 0.05$) improvement compared to the NC group, with TCW 1 being most comparable to the PC group.

The results also show that there is a marked increase in white blood cell (WBC) was observed in the NC group and neutrophils, indicating systemic inflammation. The PC group showed normalization of WBC and neutrophils. Treatment with TCW, particularly TCW 1 showed significantly ($p < 0.05$) reduced leukocytosis and neutrophilia. Lymphocyte counts, which were suppressed in the NC group, were restored in the treatment groups, especially TCW 3, suggesting recovery of immune homeostasis. The platelet count increased in the NC group, a common feature in systemic inflammation and the acute phase response. All treatment groups showed a downward trend, with TCW 1 and PC group nearing normal levels.

Effect of Coffee liberica pulp on skin and serum interleukin expression

Table 4 show, NC groups show remarkable significant ($p < 0.05$) increased all interleukins compared to the normal control group (C), reflecting strong activation of the Th17/IL-23 inflammatory axis in skin and serum. The control group showed the lowest expression levels of IL-17A, IL-22, and IL-23 in both skin and serum, confirming physiological baseline immune activity. However, for PC group, it shows that treatment with a standard anti-inflammatory agent significantly suppressed all interleukins compared to NC. The TCW1 group showed a moderate reduction in cytokine levels compared to the NC group. TCW2 exhibited a more pronounced suppression of cytokines, comparable to the positive control, while TCW3 demonstrated the greatest reduction, indicating a dose-dependent anti-inflammatory effect.

Discussion

In this study, we used *C. liberica* pulp extracts applied topically to experimental groups to evaluate their potential in either inducing or alleviating psoriasis in

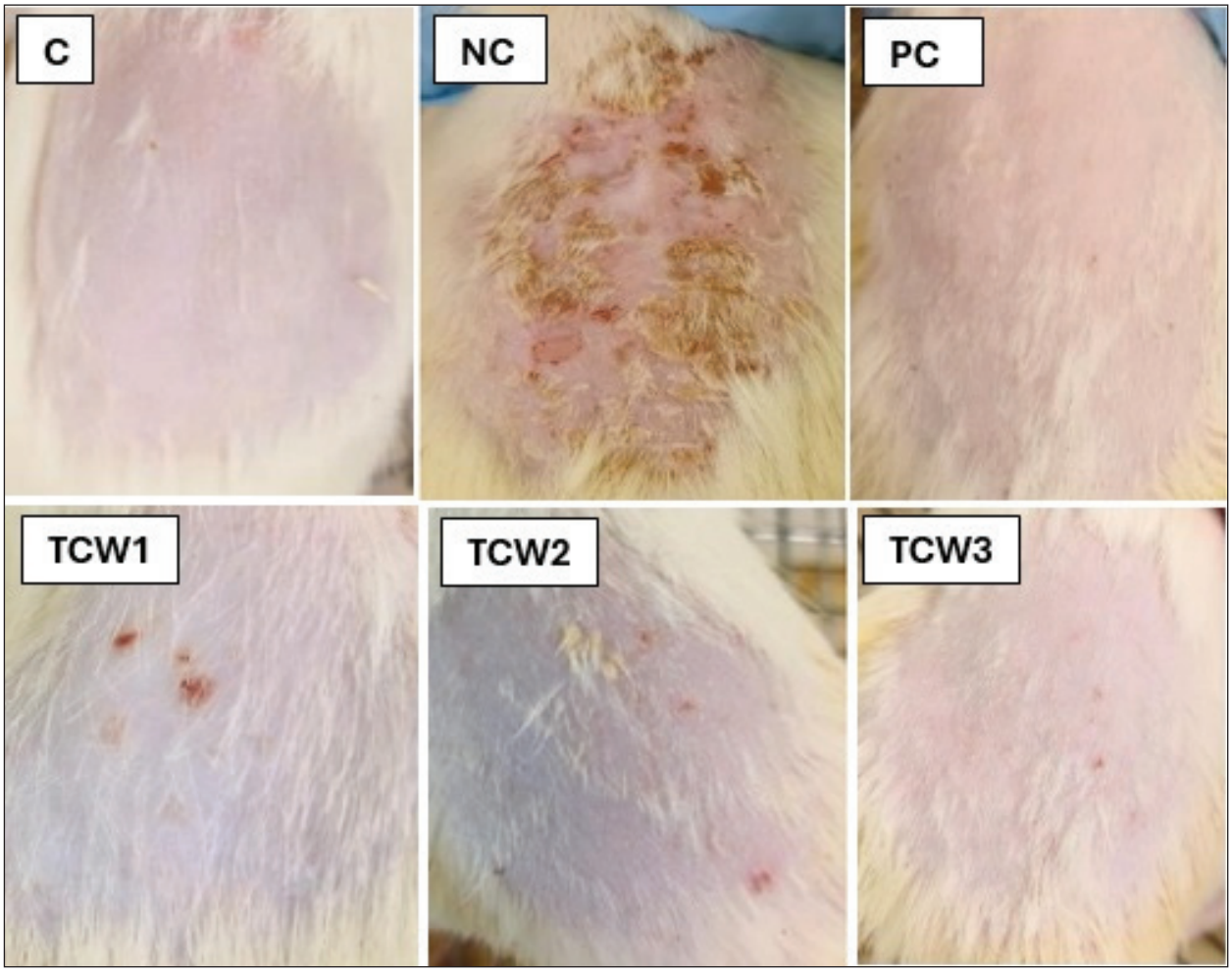

Fig. 3. Observation of Psoriasis Area and Severity Index (PASI) at day 14 from different group of rats. C, normal control; NC, negative control; PC, positive control; TCW1, mice treated with 1% extract; TCW2, mice treated with 5% extract, TCW3, mice treated with 10% of extract.

a mouse model. *Coffee liberica* pulp, a coffee-derived product, is rich in nutrients and antioxidants that offer benefits for the skin, scalp, and hair. It can also be used to exfoliate and treat acne, improve blood flow, and balance pH levels (Patay *et al.,* 2016). Therefore, the antioxidative properties of *Coffee liberica* pulp may help reduce inflammation, making it a potential treatment for psoriasis. IMQ cream plays a key role in activating the IL-23/IL-17 axis in psoriasis and induces dermatitis in mice, serving as a reliable model for analyzing pathogenic mechanisms and IL-23/IL-17 lesions that mimic plaque-type psoriasis. Induction with IMQ cream leads to increased epidermal proliferation, abnormal differentiation, neutrophil accumulation in micro-abscesses, neo angiogenesis, and infiltration of CD4+ T cells, CD11c+ dendritic cells, and plasmacytoid dendritic cells (Zhang *et al.,* 2021). Treatment with coffee pulp extract in mice led to a significant reduction in PASI scores, suggesting its potential anti-inflammatory and antiproliferative effects. The PASI is a widely used tool for assessing psoriasis severity, based on erythema, skin thickness, and scaling. The observed reduction in PASI scores following treatment indicates that coffee pulp extract may effectively ameliorate the pathological features of psoriasis. Previous research has demonstrated that coffee pulp extract contains abundant polyphenols with antioxidant and anti-inflammatory effects. These bioactive compounds can regulate inflammatory pathways, potentially reducing the severity of skin inflammation characteristic of psoriasis. In psoriasis-like mouse models, such as those induced by IMQ, the inflammatory response includes increased redness, scaling, and epidermal thickness, which contributes to higher PASI scores (Burlec *et al.,* 2024).

Studies have shown that administering coffee pulp extract can alleviate psoriatic symptoms by inhibiting key inflammatory mediators, which in turn reduces

Table 3. Effect of *Coffee liberica* pulp on Balb/C mice full blood count (FBC).

	C group	NC group	PC group	TCW 1 group	TCW 2 group	TCW 3 group
Haemoglobin (g/dl)	15.68 ± 1.03	13.15 ± 0.06	16.92 ± 0.63	16.21 ± 0.81	15.26 ± 0.34	15.22 ± 0.39
RBC ($x10^{12}$/l)	8.42 ± 0.58	6.93 ± 0.20	8.89 ± 0.34	8.51 ± 0.33	8.13 ± 0.29	8.75 ± 0.21
Packed cell volume (%)	55.40 ± 3.89	43.40 ± 0.91	56.80 ± 2.24	53.2 ± 2.07	54.2 ± 1.07	55.6 ± 1.33
WBC ($x10^9$/l)	7.60 ± 1.70	16.44 ± 1.25	8.28 ± 4.23	14.78 ± 0.98	10.44 ± 1.70	9.34 ± 0.74
Neutrophil ($x10^9$/l)	0.50 ± 0.23	7.84 ± 2.90	1.72 ± 0.09	2.32 ± 0.29	1.84 ± 0.05	1.68 ± 0.14
Lymphocytes ($x10^9$/l)	7.06 ± 1.36	4.4 ± 1.54	7.8 ± 1.31	6.38 ± 0.88	6.47 ± 1.44	8.8 ± 0.88
Monocytes ($x10^9$/l)	0.36 ± 0.20	1.94 ± 0.77	1.22 ± 0.62	0.52 ± 0.22	0.46 ± 0.16	0.42 ± 0.14
Eosinophil ($x10^9$/l)	0.16 ± 0.02	0.17 ± 0.02	0.02 ± 0.22	0.23 ± 0.01	0.24 ± 0.04	0.194 ± 0.05
Platelet ($x10^9$/l)	1060 ± 179.86	1165 ± 24.28	937.6 ± 100.65	987.4 ± 97.97	1123.4 ± 57.61	998.4 ± 12.68

Data are expressed as mean ± SEM and were analyzed by one-way ANOVA, followed by post hoc LSD. C, normal control; NC, negative control; PC, positive control; TCW1, mice treated with 1% extract; TCW2, mice treated with 5% extract, TCW3, mice treated with 10% of extract. Significant level set at $p < 0.05$.

Table 4. Effect of *Coffee liberica* pulp on Balb/C mice skin and serum interleukin expression.

Group	Interleukin 17a	Interleukin 22	Interleukin 23
Skin interleukin			
C group	18.93 ± 6.21^{b}	11.05 ± 0.85^{b}	2.73 ± 0.34^{abc}
NC group	364.88 ± 71.84^{ac}	47.59 ± 11.65^{ac}	28.47 ± 0.52^{ac}
PC group	70.59 ± 16.05^{b}	9.36 ± 5.91^{b}	5.29 ± 0.84^{b}
TCW1 group	48.86 ± 4.37^{b}	17.28 ± 5.91^{b}	7.97 ± 0.64^{bc}
TCW2 group	41.37 ± 9.58^{ab}	13.89 ± 1.97^{b}	6.51 ± 0.97^{b}
TCW3 group	36.93 ± 9.24^{ab}	13.43 ± 2.07^{b}	3.47 ± 1.28^{ab}
Serum interleukin			
C group	15.21 ± 18.45^{b}	13.30 ± 1.93^{b}	4.68 ± 0.95^{b}
NC group	220.11 ± 38.78^{a}	125.07 ± 39.75^{ac}	16.26 ± 1.99^{a}
PC group	67.90 ± 15.20	9.22 ± 1.46^{b}	6.68 ± 1.79^{b}
TCW1 group	69.34 ± 19.24^{b}	19.27 ± 0.69^{b}	12.42 ± 0.48^{abc}
TCW2 group	41.02 ± 15.99^{b}	17.53 ± 2.60^{b}	8.42 ± 0.47^{b}
TW3 group	17.48 ± 14.31^{b}	16.38 ± 4.80^{b}	6.08 ± 1.29^{ab}

Data are expressed as mean ± SEM and were analyzed by one-way ANOVA, followed by post hoc LSD. C, normal control; NC, negative control; PC, positive control; TCW1, mice treated with 1% extract; TCW2, mice treated with 5% extract, TCW3, mice treated with 10% of extract. Different superscript letters a, b and c denote significant differences at $p < 0.05$.

keratinocyte hyperproliferation and leukocyte infiltration, leading to a significant decrease in PASI scores and improvement in disease severity (Burlec *et al.*, 2024). These findings are consistent with previous reports demonstrating the anti-inflammatory and antioxidant properties of coffee-derived polyphenols, which help lower systemic inflammatory markers across various conditions (Liu *et al.*, 2019).

In psoriatic models, treatment with coffee pulp extract may also modulate FBC parameters, reflecting its influence on systemic inflammation. Psoriasis often leads to elevated WBC counts, particularly neutrophils and lymphocytes, due to chronic immune activation (Güvenç *et al.*, 2021). The polyphenols present in coffee pulp extract can help normalize WBC levels by suppressing pro-inflammatory cytokines such as IL-17A, IL-23, and IL-6, thereby reducing immune cell recruitment. Moreover, psoriasis is associated with anemia of chronic inflammation, characterized by decreased RBC counts and hemoglobin (Hb) levels. The antioxidant capacity of coffee polyphenols helps counteract oxidative stress, supporting normal erythropoiesis and maintaining stable RBC and Hb levels (Xie *et al.*, 2017). Elevated platelet counts observed in psoriasis are also linked to increased inflammatory cytokines such as IL-6; by reducing cytokine production, coffee pulp extract may normalize

platelet activity and restore hematological balance (Xie *et al.*, 2017; Nageen *et al.*, 2022).

Psoriasis is a chronic inflammatory skin disorder involving both the immune system and keratinocytes. This condition arises from the disruption of cytokines, especially IL-17a, IL-22, and IL-23, which play significant roles in triggering the inflammatory process. The potential use of coffee pulp extract as a psoriasis treatment might be related to its effects on these interleukins. IL-17a, a crucial cytokine in psoriasis, is primarily produced by the Th17 cells. It promotes keratinocyte proliferation and inflammation, resulting in the formation of characteristic plaques in psoriasis. The anti-inflammatory properties of coffee pulp extract, which are abundant in polyphenols, such as chlorogenic acids, may help decrease IL-17a levels. Studies have demonstrated that the antioxidant and anti-inflammatory actions of these polyphenols can suppress IL-17a expression, thereby reducing the inflammatory response in psoriasis models (Burlec *et al.,* 2024). Furthermore, recent studies have revealed that mice treated with coffee pulp exhibit lower levels of IL-17a in their serum and skin than the negative control group (Nakajima *et al.,* 2011; Chen *et al.,* 2016; Khueangchiangkhwang *et al.,* 2022; Nageen *et al.,* 2022). IL-22 is a critical cytokine in psoriasis as it contributes to the proliferation of keratinocytes and thickening of the epidermis. Inhibition of IL-22 is crucial for managing the hyperplastic response observed in psoriatic lesions. The bioactive compounds found in coffee pulp extract have been shown to modulate IL-22 production, potentially by interfering with the signalling pathways that activate Th17 and Th22 cells, which are the primary producers of IL-22 (Qi *et al.*, 2021). IL-23 is vital for the maintenance and expansion of Th17 cells, making it a key cytokine for sustaining the inflammatory cascade in psoriasis. Coffee pulp extract may exert its therapeutic effects by reducing IL-23 production, thereby limiting the differentiation and proliferation of Th17 cells. This could result in a decrease in IL-17A and IL-22 levels, contributing to a reduction in psoriatic inflammation (Liu *et al.,* 2019; Burlec *et al.,* 2024). Coffee pulp extract demonstrates potential in alleviating psoriasis through its immunomodulatory and anti-inflammatory actions. Its bioactive polyphenols may contribute to the downregulation of key cytokines within the IL-23/Th17 pathway, thereby attenuating inflammation and keratinocyte hyperproliferation. While these findings highlight its therapeutic promise, further studies are warranted to elucidate the precise molecular mechanisms and evaluate its clinical applicability in Psoriasis management (Nakajima *et al.*, 2011; Nadeem *et al.*, 2015; Liu *et al.*, 2019).

Conclusion

This study highlights the significant anti-psoriatic properties of *C. liberica* pulp extract, demonstrating its effectiveness in alleviating psoriasis-like symptoms induced by IMQ in mice. Compared to the application of IMQ cream alone, the extract not only improved PASI scores but also positively influenced body and organ weights, including those of the skin and spleen. These findings suggest that the antioxidant- and nutrient-rich composition of *C. liberica* pulp renders it a promising natural intervention for psoriasis.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Author contributions

SSB: Conceptualization, methodology, writing, and reviewing the original draft; AZA and HB: Conceptualization, methodology, and writing the original draft; MV and MTV: Experiment conduct, data collection and writing draft; FO and AZA: Writing—review and editing; SSB and HB: visualization; SSB: resources; CKW and MR: data analysis, and review; CKW: Editing and review; SSB: writing, editing, and review; SSB and HB: Conceptualization, methodology, and writing the original draft; FO: Conceptualization, methodology, and writing the original draft.

Data availability

All the data that support the findings of this study are available in the main text.

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